PHYSICS & TECHNOLOGY

TARGET SKILLS

- Predicting
- Hypothesizing
- Communicating results
- Conducting research

The Physics of a Car Crash

Skid marks, broken glass, mangled pieces of metal — these telltale signs of an automobile crash are stark reminders of the dangers of road travel. For accident investigators, sometimes referred to as "crash analysts" or "reconstructionists," these remnants of a collision can also provide valuable clues that will help in under-standing the cause and the nature of an accident.

The reasons for studying a car crash can vary, depending on who is conducting the investigation. Police officers might be interested in determining how fast a vehicle was being driven prior to a collision in order to know whether to lay criminal charges. Insurance companies might require proof that the occupants of a car were wearing seat belts to make decisions on insurance claims.

Government agencies, meanwhile, conduct large-scale research projects (based on both real-world accidents and staged collisions) that guide in the establishment of safety standards and regulations for the manufacture of automobiles.

Regardless of the purpose, however, most car crash investigations share some common elements. First, they typically draw on the same fundamental concepts and principles of physics that you are learning in this chapter — especially those related to energy and momentum. As well, these investigations often incorporate an array of technological resources to help with both the data-collection and data-analysis phases of the process. Investigators make use of a variety of data-collection tools, ranging from everyday hardware, such as a measuring tape and a camera, to more sophisticated instruments, such as brake-activated chalk guns and laser-operated surveyors' transits.

Customized computer programs, designed with algorithms based on Newtonian mechanics, are used to analyze data collected from the scene of the accident. The length and direction of skid marks, "crush" measurements and stiffness coefficients associated with the damaged vehicles, coefficients of friction specific to the tires and road surface — known or estimated values of these and other relevant parameters are fed into the computer programs. The programs then generate estimates of important variables, such as the speed at the time of impact or the change in speed over the duration of a collision. Quantitative and qualitative data obtained from car accidents is also often coded and added to large computerized databases that can be accessed for future investigations and for research purposes.

Recently, some automobile manufacturers have started installing event data recorders (EDRs) in the vehicles they build. Like the cockpit data recorder or "black box" commonly used in the aviation industry, EDRs in road vehicles record valuable data such as vehicle speed, engine revolutions per minute, brake-switch status, throttle position, and seat-belt use. This information is processed by a vehicle's central computer system to monitor and regulate the operation of such safety components as air bags and antilock brakes. It also provides accident investigators with an additional source of data about the conditions that existed immediately before and during a collision. As a result, EDRs promise to provide significant enhancement to the field of automobile accident investigation.

Analyze

1. Why is it important for car accident investigators to take into account the weather conditions that existed at the time of a car crash? List some specific weather conditions and predict the effects that they might have on the calculations carried out as part of an investigation.

2. Explore the Internet to learn about current research topics and technological developments related to vehicle safety. Prepare a one-page report on your research results.

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Although Kepler knew nothing about angular momentum, his second law, the law of areas, is an excellent example of the conservation of angular momentum. With somewhat complex mathematics, it is possible to write the law of conservation of angular momentum for a planet in orbit and show that it is equivalent to Kepler's second law.

Picture the movement of a unit of mass in each of the two wheels illustrated in Figure 4.11. If the two wheels are rotating at the same rate, each unit of mass in the large wheel is moving faster than a unit of mass in the small wheel. Thus, r, the distance of a mass from the centre of rotation, affects the angular momentum. The magnitude of the angular momentum, L, of a particle that is moving in a circle is equal to the product of its mass, velocity, and distance from the centre of rotation, or $L = mvr$. You will not pursue a quantitative study of angular momentum any further in this course, but it is essential to be aware of the law of conservation of angular momentum in order to have a complete picture of the important conservation laws of physics. Similar to conservation of linear momentum, the angular momentum of an isolated system is conserved.

4.2 Section Review

1. **C** Explain qualitatively how Newton's third law is related to the law of conservation of momentum.

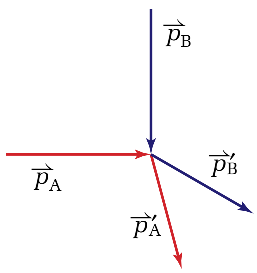
2. **K/U** What is the difference between an internal force and an external force?

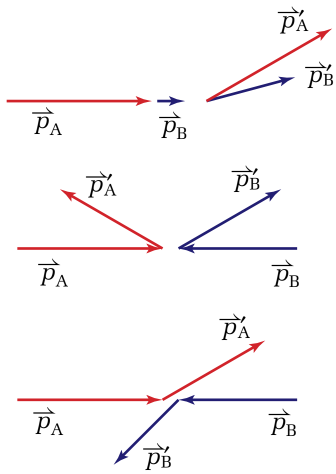
3. **K/U** How does a closed system differ from an isolated system?

4. **K/U** Under what circumstances is the change in momentum of a system equal to zero?

5. **K/U** Define and give an example of recoil.

6. **I** The vectors in the following diagrams represent the momentum of objects before and after a collision. Which of the diagrams (there might be more than one) does *not* represent real collisions? Explain your reasoning.





7. **C** Some collision problems have two unknown variables, such as the velocities of two cars before a collision. Explain how it is possible to find two unknowns by using only the law of conservation of momentum.

8. **MC** Two cars of identical mass are approaching the same intersection, one from the south and one from the west. They reach the intersection at the same time and collide. The cars lock together and move away at an angle of 22° counterclockwise from the road, heading east. Which car was travelling faster than the other before the collision? Explain your reasoning.